PROJECT facts

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

**Gasification Technologies and Advanced Research**

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# ON-LINE SELF-CALIBRATING SINGLE CRYSTAL SAPPHIRE OPTICAL SENSOR FOR TEMPERATURE MEASUREMENT IN COAL GASIFIERS

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## Description

The Photonics Laboratory at Virginia Tech has developed a novel temperature sensor based on Broadband Polarimetric Differential Interferometry (BPDI) for application in ultra high temperature harsh environments, such as those found in coal gasification systems. The sensor manipulates the birefringence of light as it is reflected by a single crystal sapphire prism and disc to determine the temperature of the surroundings. This approach is based on the measurement of the optical path difference (OPD) between two orthogonally polarized light beams in the sapphire disk. The use of single crystal sapphire was chosen for its high temperature stability and high corrosion resistance. The first phase of the project demonstrated the feasibility in the laboratory and the second phase is focused on the design and demonstration of temperature sensor so that it is suitable for use in commercial full-scale gasification systems.

Current methods to measure temperature inside a coal gasifier fail prematurely due to the extremely harsh conditions including high temperature (1300 °C) and high rates of corrosion and erosion. Since temperature measurement is a critical control parameter, premature failure impacts the efficiency and reliability of the entire system. Development of a new, robust and accurate temperature measurement system is needed to withstand the harsh conditions for an extended period of time thus allowing more efficient gasifier operation.

## Accomplishments

Phase I of the program evaluated various sensor designs and selected a BPDI-based design for its self calibrating capability, simplicity, and accuracy. Laboratory demonstration of the sensor showed that the sensor was capable of accurately measuring temperature from room temperature up to 1600 °C with a resolution of approximately 0.26 °C. Laboratory testing also showed that the single crystal sapphire material was highly resistant to penetration or corrosion from coal slag that is formed in coal gasifiers and is highly erosive and corrosive.

## PARTICIPANT / PRINCIPAL INVESTIGATOR


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## PROJECT COST

| | |
|---|---|
| **Total** | $1,339,942 |
| DOE | $1,066,482 |
| VPI | $273,460 |

## PROJECT DURATION

10/01/1999 -09/30/2005

## WEBSITES

www.netl.doe.gov/coal

The data generated in laboratory testing showed excellent repeatability and compared well with that for the B-type thermocouple used as the standard. An example of some of the data generated in the laboratory-testing phase is shown in Figure 1. The schematic setup of the system is shown in Figure 2.

Current research efforts have been focused on designing the sensor's mechanical packaging. Virginia Tech has teamed with Conoco/Phillips Wabash River Power Plant to finalize the design of the sensor and test the sensor prototype at full scale. The mechanical structure has been simplified and the stability of the system increased with a new sensing probe design. The sensor will be tested in Spring 2004 followed by a second test to optimize performance.

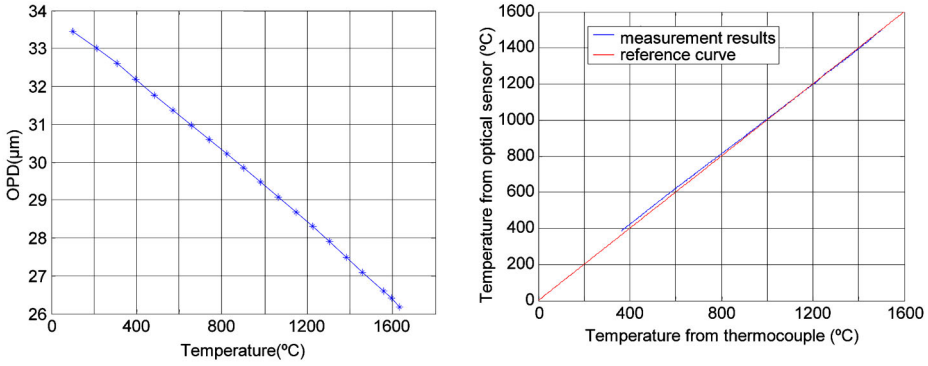


*Figure 1. BPDI temperature sensor laboratory testing results compared to B-type thermocouple.*

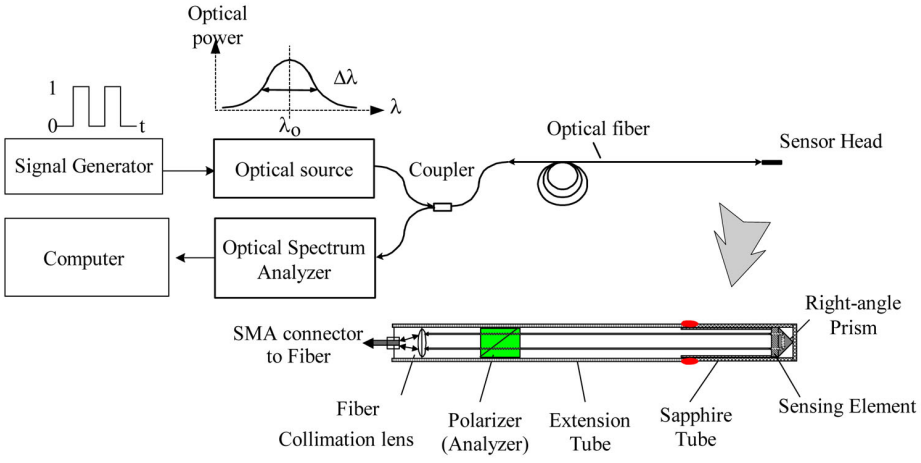


*Figure 2. Schematic of the single-crystal sapphire based optical high temperature sensor.*